RADIO and ELECTRONICS

Wellington Heads by Radar

INCLUDED IN THIS ISSUE:

MAY, 1946

MOBILE POLICE RADIO.
THE "RADEL ONE".
SIGNAL-TO-NOISE RATIO.
THE INFINITE IMPEDANCE MIXER.
RADIO ON THE LANCASTRIAN.
A FIVE INCH SERVICE OSCILLOSCOPE.

1'6

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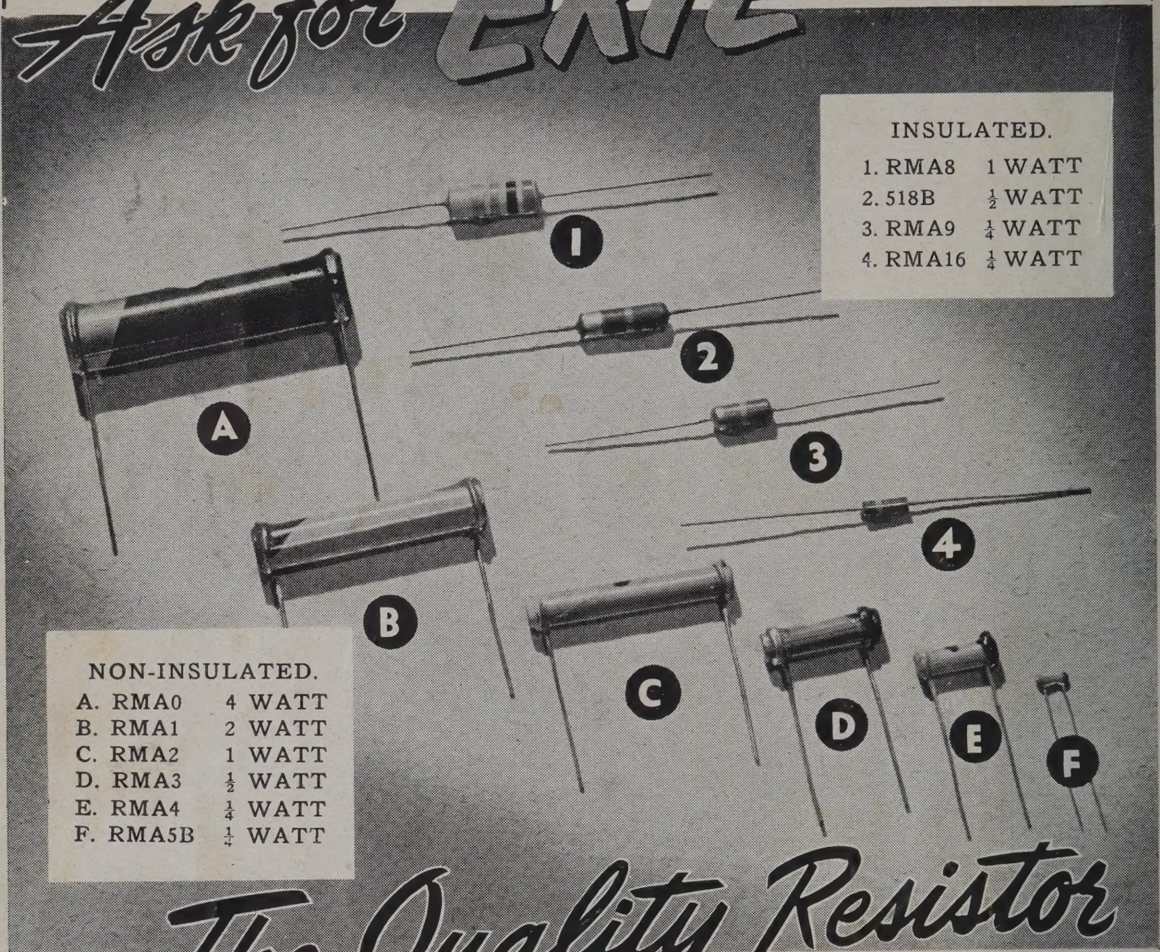

INSULATED.

1.	RMA8	1 WATT
2.	518B	½ WATT
3.	RMA9	¼ WATT
4.	RMA16	¼ WATT

NON-INSULATED.

A.	RMA0	4 WATT
B.	RMA1	2 WATT
C.	RMA2	1 WATT
D.	RMA3	½ WATT
E.	RMA4	¼ WATT
F.	RMA5B	¼ WATT

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RADIO and ELECTRONICS

Vol. 1 No. 2 May 1946

Contents Page

OUR COVER

This month's picture compares side by side a radar presentation of Wellington Heads as seen from a ship outside the harbour, and a map to the same scale, of the area covered by the radar map.

CORRESPONDENCE

All correspondence, contributions, and enquiries referring to advertising space and rates should be addressed to:—

The Editor,
"Radio and Electronics,"
Box 22,
Government Buildings P.O.
WELLINGTON.

NEXT MONTH

For Servicemen and Amateur: Circuit details of the first portion of the home-built secondary frequency standard for use with WWV. Also the first of Radio and Electronics Design Sheets.

Published for the proprietors by FEATURE PRODUCTIONS, P.O. Box 5065, Wellington.

Techniques— British or American?

Whose technique will prevail in New Zealand now that many radio men have been to England and have gained experience at first hand of British methods and equipment?

Before the war, most of our equipment and technical literature on radio and allied subjects came from the United States. It is not intended here to moralise on this, nor yet inquire how such a situation arose. Suffice it to say, that in spite of the fact that British sets and components were being imported in increasing quantities immediately prior to the war, the average amateur and home-constructor turned to American designs, to the almost complete exclusion of anything British. There were many reasons for this, but high among them were that British valves were uncommon and had "funny" bases, and that to one used to American publications, British circuit diagrams looked peculiar and were therefore difficult to read. The result was that British radio was an unknown quantity to the New Zealand radio enthusiast.

We now know that Great Britain was first on the operational scene with the most important electronic device of the war, Radar. Not only was she first in the field, but she led it to the end, and to such good purpose that at no stage were our enemies able to catch up with allied developments. Many people, too, are not aware that England initiated the regular service of high-definition television.

Perhaps after all there **is** something in British valves, technique, and even circuit diagrams. Those who had the good fortune to go to England during the war, to work with British people and British equipment, have returned with a hearty respect, founded on first-hand knowledge, for British radio in all its phases. Many New Zealanders have had to become conversant with British circuit drawing and valves, so that now they are bi-lingual in terms of radio. New Zealanders have seen in Britain radio techniques and equipment that are magnificent, and whose story should be told in the greatest detail, to prove to those that still need proof that the British radio industry is second to none.

We do not wish it to be said that by trying to atone in some measure for past neglect, we decry or even minimise the enormous contributions to radio by the United States. Our plea is simply for recognition where recognition is due, and our thesis is that New Zealand should look to Great Britain as well as to America for leadership in radio.

As a radio magazine we should be failing in our duty to the radio-minded public were we to ignore things British, as has been done in the past. This publication's principle is to give the reader the best and most up-to-date information, irrespective of origin. The reader may even, at times, find himself encouraged to use British or Continental valves with "funny" bases; but let him not be deterred by unfamiliarity for any such advice will be backed by good radio engineering principle, and practice.


ELECTRONICS
made it possible!
Hullo, Red Section, tanks at nine o'clock — follow me—and as one well-knit unit the flight goes hurtling down to its target, tied together with an invisible electronic link. Close command in the air depends on radio communications, and at the heart lies the electronic valve.
OSRAM VALVES were in the forefront of electronic development during the war, and have brought to the pursuits of peace many well tried electronic devices to speed, smooth and make safer our way of life.
Many OSRAM VALVES now on the secret list will be available when priority production ceases to meet the needs of electronic designers in every sphere.
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Osram PHOTO CELLS
G.E.C. CATHODE RAY TUBES
Osram Valves
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WELLINGTON AUCKLAND
CHRISTCHURCH DUNEDIN

THE LANCASTRIAN

Aviation and electronics are indissolubly associated; the aircraft is a triumph in aerodynamic engineering but numerous pieces of complex ancillary equipment depend upon a new science as phenomenally progressive as aviation—electronics. While it is not possible here to discuss electronics as applied to aviation generally, these photographs serve to illustrate the uses to which electronics have been put in combating one of the greatest hazards of flying—that of aerial navigation.

A record-breaking dash as made by the Lancastrian from England to N.Z. and back again is truly remarkable, but it is a sign of things to come, for in a very short time such events will be commonplace. The Captain of an aircraft engaged on flying over long sea "hops" must have vital and accurate information instantaneously and reliably. In particular, meteorological data must be available at all points en route, and in addition, the navigator must have means of checking his dead reckoned position.

Radio communications and radar navigational aids have indisputably proved themselves in wartime, and need little conversion to civil aviation applications. The photograph on this page shows the wireless operators' compartment and the radio installations. At the extreme left is the aircrew inter-communication system and adjoining it, is

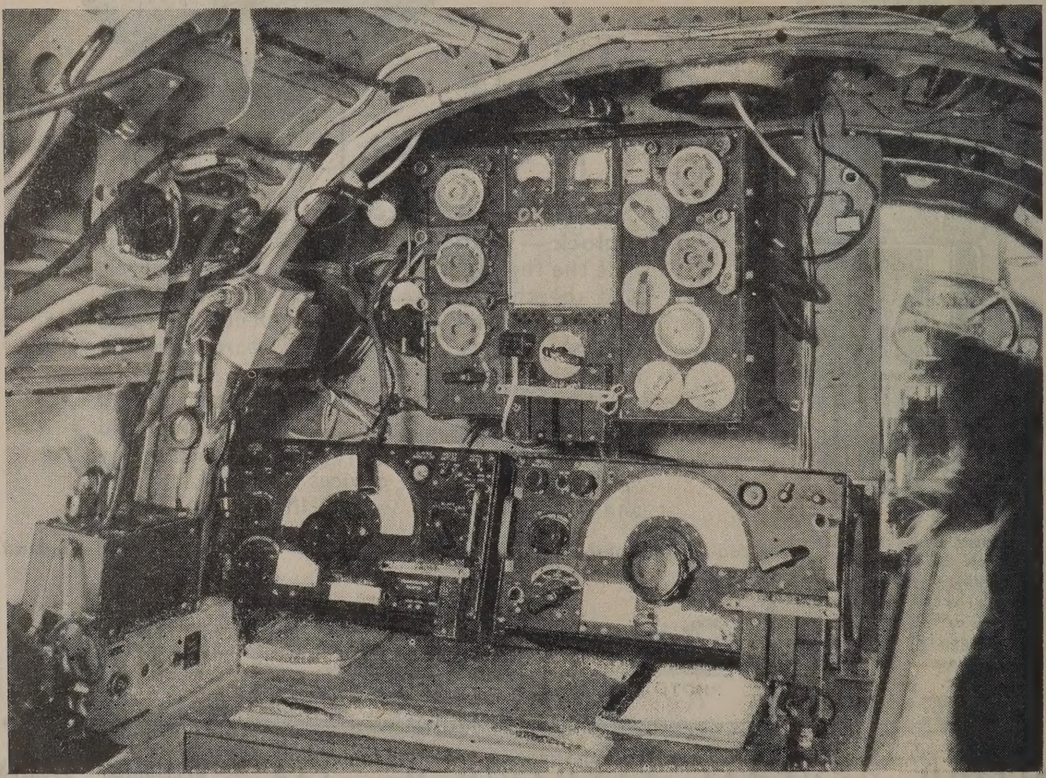


PHOTO BY PERMISSION OF R.N.Z.A.F.

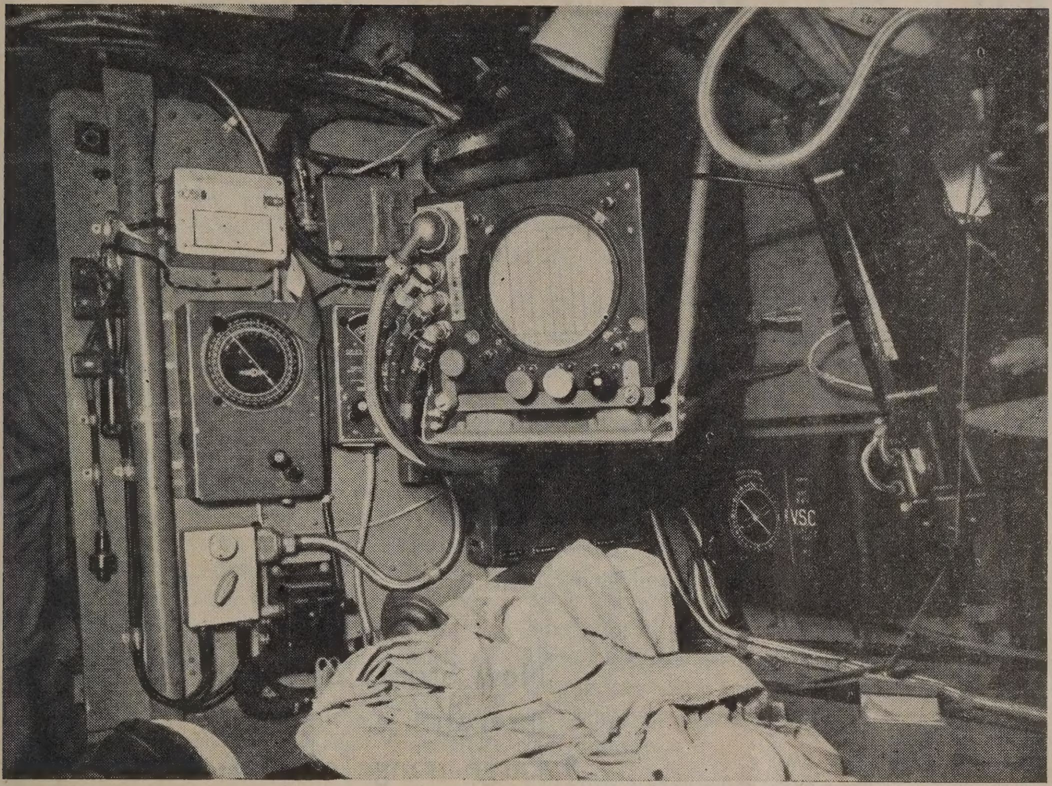


PHOTO BY PERMISSION OF R.N.Z.A.F

the communication receiver—a light-weight set which will do all that is expected of any receiver. To the right of that again is the radio direction finding receiver. The associated D.F. loop can be seen attached to the aircraft skin at the top of the compartment.

The transmitter is located immediately above the two receivers, and is a flexible multi-band 'phone and C.W. set. A range of frequencies is pre-set, and this factor combined with the versatile characteristics of the complete radio installation maintains the aircraft in constant contact with the ground.

The second photograph illustrates the equipment installed in the navigator's compartment, and in prominence is the radar homing and ranging indicator. The word "radar" here is a slight misnomer, for although the system employed utilises the pulse system, it does not involve the reception of an "echo." This type of equipment will be dealt with in our series of radar articles; consequently, there is little need to discuss the apparatus in detail. To the left of the radar indicator is the azimuth control of the D.F. loop. Shown on the extreme right is the side view of the "Loran" radar indicator. Again, this is a highly complex piece of equipment and will shortly be described completely by "Radio & Electronics".

This article is intended pictorially, rather than graphically to describe the electronic equipment associated with aviation; we feel sure you will agree—it does.

A 5" SERVICE OSCILLISCOPE

Built at very moderate cost from parts available today, this instrument has many features found only in high-priced commercial oscilloscopes.

No one would claim that an oscilloscope is an indispensable piece of equipment to the serviceman or amateur enthusiast, yet it has very many uses even in the daily round of fault-finding in receivers and transmitters. To those who design their own equipment, an oscilloscope is almost invaluable, for it enables many tests and measurements to be made that cannot otherwise be performed without much more specialised and costly equipment. To the serviceman who has learned to use it, the oscilloscope is a great saver of time, and can do duty for several pieces of test-gear. Many men who have worked at radio in the forces have become familiar with the cathode ray tube, and (especially those who have been radar mechanics) are wondering how they ever got on without one.

At a time when practically everyone is back in "civvy street" and when some hundreds are establishing themselves in radio businesses, we feel that the time is opportune for a series of articles describing the design and construction of a range of modern test-equipment. Of this series the oscilloscope is the first; this will be followed by descriptions of other items, which, taken together, will form a complete serviceman's test bench.

OUTSTANDING FEATURES.

Though in no way pretending to be a "'scope to end 'scopes," this one embodies a number of features which give it performance well out of the ordinary. Primary considerations in the design have been ease of operation, and high performance from the tube and associated circuits.

CHOICE OF TUBE.

The cathode-ray tube chosen for the oscilloscope is the 5GP1/5BP1. This is a modern American 5-inch tube, and has all deflecting plates brought out to the base. This is a very great advance over the old style of tube which had one each of the X and Y deflecting plates connected together internally. This meant that only unsymmetrical deflection could be used, together with unbalanced shift controls, and no provision for astigmatism control. With this type of tube the purchaser was at the mercy, as it were, of the manufacturers, for imperfections in the tubes could not be compensated by electrical means, as can be done with those tubes which have all electrodes brought out.

BALANCED DEFLECTION.

Balanced or push-pull deflection circuits have been used for both X and Y axes. The slight complication involved pays handsome dividends in increasing the quality of the image. The latter is rendered sharp right to the edges of the screen. Trapezium distortion is eliminated, as is deflection defocussing.

The circuit used for the balanced deflection amplifiers is one described by O. S. Puckle in his book, "Time Bases." It will be described in detail later, but it may be emphasized here that to this circuit are due the excellent operating characteristics of the 'scope and the delightfully simple means of obtaining balanced shift and astigmatism control voltages.

SHIFT AND ASTIGMATISM CONTROLS.

One reason why commercial oscilloscopes rarely provide balanced deflecting circuits is that these necessitate balanced shift voltages. The latter, in turn, require special components such as ganged potentiometers. These are unobtainable in this country, and in any case are never balanced with any great degree of accuracy. The cathode-coupled deflection amplifiers enable balanced shift voltages to be obtained from the amplifier itself, and with the same accuracy that is realised for the deflecting signals, so that this circuit confers advantages additional to those it possesses simply as an amplifier.

The writer does not know of a single commercial oscilloscope which provides for control of astigmatism. Certainly this is in the nature of a refinement, and is used as a rule only in large tubes (12in diameter or over), but as long as cathode ray tubes are expensive astigmatism control is a matter of practical economics, since it can render passable a tube that is almost unusable without it. Astigmatism is a fault of the tube itself, and occurs when one or more of the electron-gun components is out of alignment. The

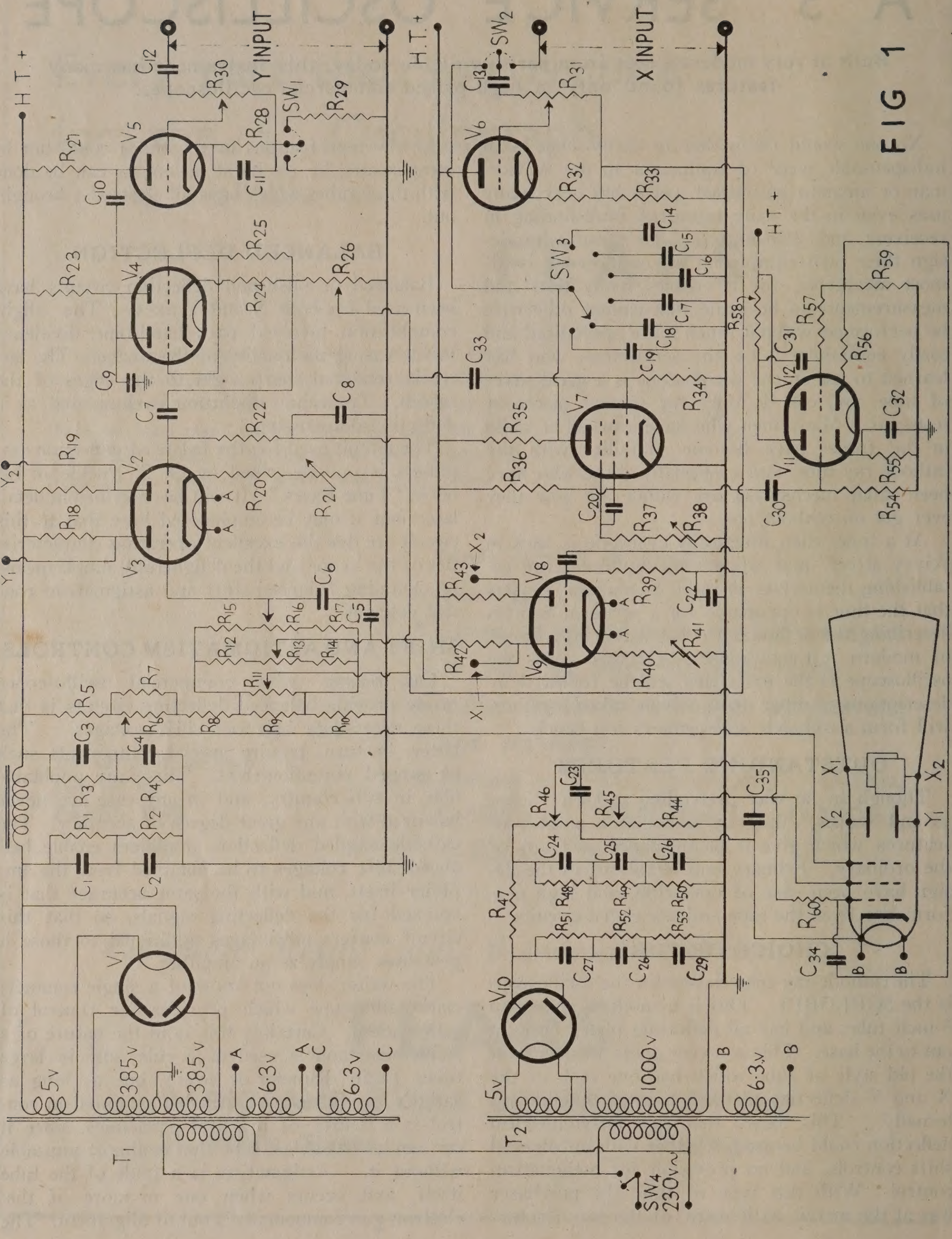

Y INPUT
X INPUT
H.T. +
SW1
SW2
SW3
SW4
230V~
T1
T2
5V
385V
385V
6·3V
6·3V
1000V
6·3V

FIG 1

COMPONENT LIST.

C_1-C_4 = 16 μf. Electrolytic.
C_5, C_6, C_{14}, C_{20}, C_{23}, C_{24}-C_{29} = 1 μf. 600 v paper.
C_9 = 8 μf. Electrolytic.
C_{11}, C_{32} = 50 μf. 50 v. Electrolytic.
C_{15} = 0.25 μf. 600 v.
C_{16} = 0.05 μf. 600 v.
C_{17}, C_{33} = 0.01 μf. 600 v.
C_{13}, C_{30}, C_{31} = 0.1 μf. 600 v.
C_{18} = 0.002 μf. mica.
C_{19} = 0.0005 μf. mica.
C_{34} = 0.25 μf. 1200 v. (see text)
R_1-R_4, R_{22}, R_{25}, R_{39}, R_{44}, R_{54}, R_{57}, R_{60} = 1 Meg.
R_5, R_8 = 10 k.
R_9, R_{10}, R_{12}, R_{15} = 25 k.
R_{14}, R_{17}, R_{34}, R_{37}, R_{55}, R_{58}, R_{59} = 50 k.
R_{18}-R_{20}, R_{27}, R_{29}, R_{33}, R_{36}, R_{40}, R_{42}, R_{43}, R_{47} = 100 k.
R_{23} = 75 k.
R_{24}, R_{28}, R_{32} = 5 k.
R_{35} = 150 k, 2 w.
R_{48}-R_{53} = .5 Meg.
R_{56} = 600ω.

POTENTIOMETERS.

R_6, R_{11} = 0.5 Meg.
R_{13}, R_{16} = 50 k.
R_{21}, R_{26}, R_{41} = 25 k.
R_{30}, R_{31}, R_{38} = 2 Meg.
R_{45} = 1 Meg.
R_{46} = 1 Meg. Pot. with 100 k fixed, in parallel.

T_1 = Power Transformer, 385 v. a side.
T_2 = High Voltage Transformer.
Sw_1 = Y gain switch.
Sw_2 = X input switch.
Sw_3 = coarse freq. selector.
Sw_4 = on/off switch.

visible effect of this is that the spot is elongated in some direction, or (what is the same thing) some parts of the image are out of focus when others are sharp.

The remedy, which can only be applied only when balanced deflection is used, is to vary the mean potential of each pair of deflecting electrodes. This is done by a process of trial and error until a circular spot is obtained, or until the whole image is in focus at once. As a rule, astigmatism controls call for some complication of the shift circuits, but when the cathode-coupled amplifier is used the problem is solved in a very simple fashion.

A further refinement provided in the present instrument is that the shift controls are instantaneous in their action. There are no coupling condensers to charge up, since the deflecting plates are tied directly to the anodes of the amplifier valves.

SUMMARY OF FEATURES.

Before proceeding to describe in detail the circuits involved, here is a list of the special features of the oscilloscope:—

(1) Balanced deflection and shift voltages.
(2) Instantaneously-acting shift controls.
(3) Astigmatism controls for both axes.
(4) "Transitron" hard-valve time-base, with a frequency range of 16 — over 50,000 cycles/sec. Higher sweep frequency may be obtained if desired.
(5) Time-base fly-back blacked out by feeding a pulse to the C.R.T. grid.
(6) Provision for direct connection to deflecting plates.
(7) Two-stage Y-axis amplifier, with high/low gain switch. In the low gain position the Y amplifier has the same gain as the X amplifier, facilitating the production of Lissajous figures.
(8) Internally - connected synchronisation control for the time-base.
(9) Cathode-follower buffer stages used whenever long signal leads have to be run, giving low hum pick-up and improved high frequency response.
(10) Independent action of time-base frequency and amplitude controls, making for ease of operation.

(11) Short time-constant circuit feeding the synchronising voltage to the time-base valve as an aid to positive synchronisation.

THE CIRCUIT IN DETAIL.

The full circuit diagram is given in Fig. 1. There are nine valves in all, exclusive of the cathode ray tube itself, and their functions are as follows: 2 Type 80, rectifiers; 2 Type 6N7, deflection amplifiers; 1 Type 6J5, X-axis cathode follower; 1 Type 6J5, first Y-axis amplifier stage; 1 Type 6AC7/1852, time-base valve; 1 Type 6N7, Y-axis cathode-follower; 1 Type 6SN7-GT pulse amplifier and cathode follower (black-out tube).

In describing the whole circuit, it is convenient to break it up into sections. Fig. 2 is a block-diagram showing the general arrangement of the stages and their relation to each other.

THE CATHODE-COUPLED AMPLIFIERS.

The appearance of these stages on the main circuit diagram is somewhat complicated by their connection with the power supply. Fig. 3 is a simplified version of either of them, with the shift and astigmatism controls removed. The symbol between the valves represents one pair of deflecting plates of the C.R.T. E_1 is H.T. +, about 500 volts, while E_2 is a tapping at approximately 200 volts. It should be remembered in considering circuits like this, where electrodes are at unusual potentials, that all tappings on the power supply voltage divider are at earth potential as far as signal is concerned, although their D.C. potential may be highly positive or negative. Thus, since the grid of V_2 is directly connected to the power supply, it is at earth potential for signal purposes.

R_3 is a large resistor common to both cathodes. Since its value is large (say, 100,000 ω), it places the cathodes at a high potential above earth. In order that the tubes shall not there fore be biassed almost to cut-off, the grid of V_2 and the lower end of the grid resistor of V_1 are returned to the positive potential E_2. The valves are therefore normally biased a few volts negative, in spite of the unusual voltages on the grids and cathodes.

One way of regarding this circuit is as follows: A signal applied to the grid of V_1 produces a signal in the same phase, across R_3. Since R_3 is

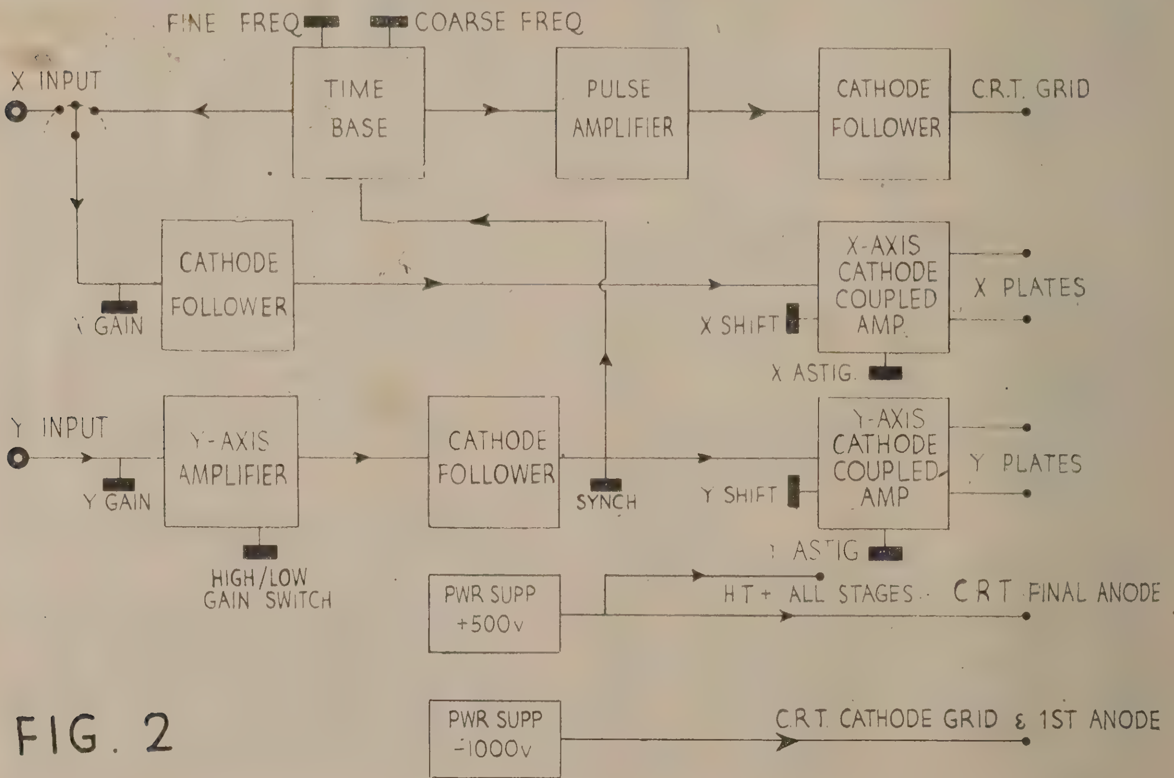
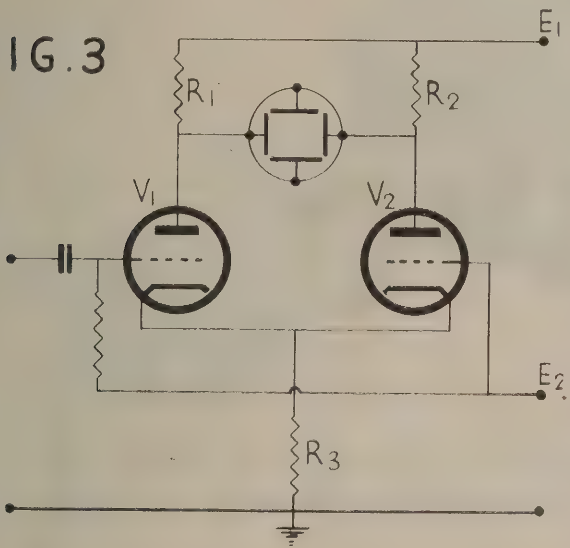


FIG. 2

large, V_1 acts partially as a cathode follower, and the signal at the cathode is almost equal in magnitude to the input signal. Now the grid of V_2 is effectively earthed for signal, and its cathode is tied to that of V_1. V_2 therefore receives a signal almost equal to the input signal in magnitude, but effectively 180 degrees out of phase with it, since it is applied to the cathode. Since the valves have equal plate load resistors, R_1 and R_2, equal and out-of-phase signals appear at the anodes of the valves, and are applied directly to the X or Y deflecting plates of the C.R.T.

The above explanation leaves something to be desired in completeness, but does give some idea of how the circuit operates. In any event, this type of stage produces push-pull voltages matched to within a few per cent.

FIG. 3



Due to the large cathode-resistor, the circuit has the valuable property that if one valve becomes cut off, the other functions as a cathode follower. As a result, it is difficult to drive the stage into grid-current. Even if this occurs, the current is much less than would be drawn by a normal amplifier stage if overdriven.

As has been mentioned above, the shift voltages are produced by the cathode coupled stages. These voltages are obtained by modifying the grid-return circuits from the simple form shown in Fig. 3. Returning to the main circuit diagram, and considering the Y-axis cathode coupled stage, it can be seen that the by-passed lower end of the grid resistor of V_2 is returned to the moving arm of the potentiometer R_{11}. This is a pre-set control, used only in the preliminary adjustment of the 'scope. If no shift voltage was to be provided, the grid of V_3 would also be returned to this point, and the circuit would correspond exactly to Fig. 3. However, the network comprising R_{15}, R_{16} and R_{17} in series is shunted across R_{11}, and the grid of V_3 is connected to the moving arm of R_{16}. It is thus possible to adjust the D.C. potential of the grid of V_3 so that it is equal to, greater, or less than that of the grid of V_2.

If the grids of V_2 and V_3 are at the same potential, conditions are again exactly as in Fig. 3, and the spot will be centered on the screen. But suppose that the grid of V_3 is made negative with respect to that of V_2. V_3 will draw less current, and its anode potential will rise. The cathode coupling comes into action (exactly as in the case where *signal* is applied to V_2), and the anode potential of V_2 will fall by an equal amount. The movement of the shift control has therefore caused equal and opposite changes to occur in the anode potentials of the two valves. Since the Y-plates of the C.R.T. are directly connected to the anodes of V_2 and V_3, equal and opposite changes also occur in the potentials of the X-plates. The electron beam is attracted by the plate that has moved in a positive direction and repelled by the other plate, which has gone negative, so that the spot shifts in the X direction by an amount proportional to the difference of potential between the plates. Had the grid of V_3 been made positive with respect to that of V_2, the shift would have been to the opposite side.

It can be seen that the valve circuit itself produces large, balanced shift voltages from a small, unbalanced voltage applied to the grid of V_3, advantage being taken of D.C. amplification by the stage. All other methods for obtaining balanced shift voltages require an arrangement of ganged matched potentiometers, and either a separate "floating" power supply, or else a complicated network across both the positive and negative power supplies in the oscilloscope.

ASTIGMATISM CORRECTION.

This is provided for each axis by its cathode-coupled amplifier. The power supply circuits are so arranged that the final anode of the C.R.T. is at the same D.C. potential as the deflecting plates. If this is not so, the spot is de-focussed, and no amount of adjustment of the focus control will rectify matters. However, adjustments of several volts either way to the potentials between the final anode and each set of deflecting plates may

(*Continued on Page* 28).

MEASUREMENT OF FREQUENCY

PART II.—USING THE STANDARD FREQUENCY BROADCASTS.

In Part I of this series, the standard frequency broadcasts of Station WWV were described in detail, and a very brief outline was given of the equipment and technique required for exact measurements by means of these transmissions. For the exact measurement of any frequency, a considerable amount of equipment is necessary. Building this should not present undue difficulty to a careful constructor, and it is not expensive to produce, but for some purposes all of it is not required.

A home-built secondary frequency standard for use with WWV can therefore be a progressive affair, containing just as much as is necessary for the particular job in hand, and space for the addition of a few more valves which will convert it into a very complete instrument. Such a secondary frequency standard will be described later in this series; readers by that time will have been able to decide exactly what their own requirements are, and can therefore build just as much of the standard as meets those requirements.

A RECEIVER ONLY.

Since the standard frequency under discussion is a signal on the air, the first requirement is a receiver of some kind. In fact, a receiver may be regarded as the simplest kind of secondary frequency standard, since it enables direct comparisons to be made with the frequency of WWV. Since all use of WWV depends upon the receiver, it should be a good one. The signal that can be expected is quite good enough to be easily received on a simple regenerative receiver, and this type of set has one great advantage—namely, lack of spurious responses. A good superheterodyne is to be preferred, however, in spite of the fact that care must sometimes be taken to ensure that image response is not being obtained. The reason is one of stability, selectivity, and ease of operation. Even a battery-operated regenerative set is not very stable over a period of several minutes to, say, half an hour, and the almost invariable "fiddling" required to keep the receiver "on the nose" is a decided disadvantage.

The most desirable superheterodyne is a communications receiver, but this is not absolutely necessary. Any good super will do provided either that image response is negligible, or else that images can be recognised as such. In some cases they cannot, so that the more selectivity ahead of the mixer stage the better. A selective I.F. channel is also an advantage, but it is not quite so important since WWV on 10 and 5 Mc/sec is usually clear of adjacent channel interference.

We will assume, then, that the would-be user of WWV has a receiver which can satisfy the requirements outlined above. What can be done by way of frequency measurement without any further equipment? Not very much, but some quite useful things nevertheless.

CHECKING AN ALREADY CALIBRATED OSCILLATOR.

Suppose that a test oscillator or signal generator has been dropped or otherwise mishandled, and it is suspected to have gone off calibration. Whether it has done so or not can be checked with the receiver as the sole equipment; the procedure is as follows:—

(1) Tune in WWV on 10 Mc/sec and adjust the volume to a suitable level. If the receiver is a superhet., the B.F.O., if any, should be turned off.

(2) The signal generator, having been allowed to warm up, is tuned to 10 Mc/sec, and its output is coupled very loosely to the aerial lead of the receiver. If the signal from the generator is within five or six kc/sec. of the correct frequency of 10 mc/sec., a beat note will be heard in the receiver. The exact audio beat frequency is the difference between the radio frequencies of WWV and th signal generator.

HIGH/LOW DETERMINATION.

In all frequency checking or measuring processes, one must know whether the frequency being checked is higher or lower than that of some standard frequency—in the above case, that of WWV itself. It is necessary, therefore, to have a rule-of-thumb method for settling this point, which is very open to ambiguity, and not quite so simple as it appears at first sight.

Referring to the case described in the preceding paragraphs, it is required to find whether the signal generator frequency when set to its nominal figure is too high or too low by the value of the beat frequency. This may be done by tuning

the signal generator until "zero beat" is obtained. Having done this, either of two things may be used to answer the high/low question. The first method is to note which way along the scale the pointer was moved *from* the nominal frequency mark *to obtain* zero beat. The other way is to note which way along the scale the pointer must be moved to return it *to* the nominal frequency mark *from* the point where zero beat was obtained. These two methods obviously work in the same way but with different directions of movement, so that there is plenty of room for ambiguities to creep in if care is not taken. The answers to the two methods are as follows:—

(1) If the pointer in moving from the nominal frequency mark to the point of zero beat moves towards the high frequency end of the scale, the signal is too low when set to the nominal frequency.

(2) If the pointer in moving from the point of zero beat to the nominal frequency mark moves towards the high frequency end of the scale, the signal is too high when set to the nominal frequency.

Some time has been spent on this matter, as it is an important one in frequency measurement, and it is as well to clear it up at the outset. In the example quoted, the signal generator may have been so much out in frequency that no audible beat note could be heard on coupling it to the receiver. If this is the case, the signal generator must be re-tuned until a beat note is heard. It is then set to zero beat, and the high/low determination made. Since no other equipment is being used, the amount by which the frequency of the generator is in error may be estimated by the *amount* of the shift in the pointer to go between the two points—that of zero beat, and the nominal frequency point on the scale. For example, if the point of zero beat were 10.1 mc/sec. on the scale, the signal generator would be approximately 100 kc/sec. *low* when set to the 10 mc/sec. mark.

The preceding paragraphs are a detailed description of the most important steps in any frequency measuring process. In the example used, "matching" the unknown with the known, or standard frequency, followed by the high/low determination constitutes the complete measurement. In all other cases these two steps are still those requiring most care, so that space devoted to describing them may be considered well spent.

USE OF HARMONICS.

A single standard frequency, as is constituted by one of WWV's transmissions, can be made more useful by the employment of harmonics. For instance, returning to our imaginary signal generator that requires checking, so far all we have managed to accomplish is a single check at 10 mc/sec.—only one point on one wave-band. By the use of harmonics of the signal generator, other points may be checked.

10 mc/sec. is the second harmonic of 5 mc/sec.; similarly, it is the fourth harmonic of 2.5 mc/sec., the eight of 1.25 mc/sec. and so on. Thus, if the signal generator output is rich in harmonics, many of the points may be checked by an exactly similar process to the one already described. For example, to check the 5 mc/sec. point, all that needs to be done is to set the signal generator to 5 mc/sec. and listen for a beat-note in the receiver, as before. This time the second harmonic of the signal is beating with the standard frequency of 10 mc/sec.

Considerable care should be exercised in using harmonics in this way, especially where the receiver used is a superheterodyne. Subsidiary beat notes may be heard which arise from harmonics of the receiver's local oscilator and harmonics of the signal generator or other "unknown" frequency source. A simple check will reveal whether a beat note is one of these spurious ones or not. Detuning the receiver slightly will alter the frequency of the beat note if it is a spurious one since detuning alters the frequency of the local oscillator. A "true" beat, i.e., one between WWV and a harmonic of the unknown frequency will not alter in pitch as the receiver is detuned.

Another point requiring some careful manipulation is that if high harmonics of the unknown frequency are being used, such as the seventh or eighth, uncertainty is likely to arise as to just which one is producing the beat note that is observed. The harmonic method, though helpful in extending the usefulness of a single standard frequency, should be used sparingly owing to the possibilities of error it introduces.

AUXILIARY EQUIPMENT.

It is clear that a single standard frequency in conjunction with a receiver alone can at best provide only a few points at which frequencies may be checked. If the standard frequency is to be of much use, then means must be found

(*Continued on Page* 29).

MOBILE POLICE RADIO

By M. M. Macqueen,
The General Electric Co., Ltd., England.

Nottingham, one of the pioneers of police radio, has adopted the most modern system of radio telephony to combat crime—with staggering results.

The system, known as V.H.F. (very high frequency) operates over a waveband unused by any other form of radio broadcasting or television. The result is that transmissions are as free from outside interference as a normal telephone conversation and cannot be "picked up" by ordinary civilian radio equipment.

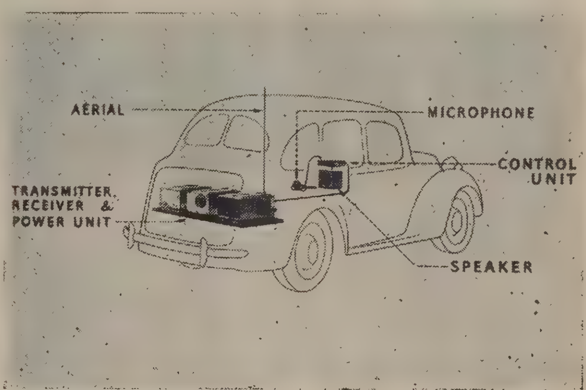
The radio equipment is controlled from an operations room, elaborately equipped by Police technicians of the Nottingham Force. It enables every patrol car to be in constant radio-phone communication with police headquarters. Every report of crime in the city requiring immediate and speedy action is treated as a military operation, and so effective has the new system proved that since it was installed smash-and-grab raids in the city have been reduced by 80 per cent., and car thefts by 50 per cent.

One wall of the operations room is covered by a large map of Nottingham. This is mounted on a panel which is wired up so that red lights indicate the location of the patrol cars—called "uniform cruisers". As soon as the cars change their position, the officer in charge of the control room turns a switch; the red lights are changed to indicate the new positions of the vehicles and a panel by the officer's side illuminates the names of the streets to which all the cars have moved. This happens when the cars move on their normal beat or when the officer in the operations room orders them to new positions for a specific action.

An order broadcast from the operations room can "seal" the city in two and a half minutes, i.e. uniform cruisers can be moved to pre-arranged strategic points to man every road leading in or out of the city. To effect this, the officer merely broadcasts "action" (giving the code number of the appropriate action) and every patrol knows where to proceed.

Other actions are designed for various manoeuvres—e.g., to surround the Park, to close the north, south, east or west approaches to the city or to assemble a concentration of vehicles at a specific point (when a man is believed to be on lock-up premises or a suspicious light is seen in a bank).

The system also makes it possible to put a police constable on any doorstep in Nottingham in two or three minutes.



The uniform cruisers are heavy, high-powered cars, and are each equipped with a mobile transmitter and receiver operated from a 12-volt battery. In Nottingham these cruisers do not carry a separate operator, so the microphone has been fitted to an adjustable rod above the windscreen and the driver can broadcast on the move while retaining full control of the car.

More than 100 messages a day are broadcast over this system. They are picked up simultaneously by all the uniform cruisers on duty, by the police sergeant in charge of the garage (who details "chaser" motor-cycles to join in the operation as required) and by four police stations in the city from which foot patrols and motor-cycles may be despatched as necessary.

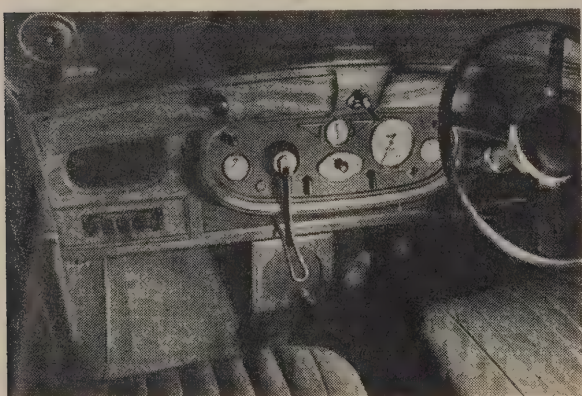
The Chief Constable himself—Capt. Athelstan Popkess, O.B.E.—can "listen in" to every action in his office and, if he chooses, by direct communication with his operations room, he can direct the action from his desk.

Also equipped with mobile transmitters and receivers are special patrol vehicles which are not

recognisable as police cars. They are used by the C.I.D. and are driven by plain-clothes men. One of their chief functions is to patrol residential areas where there have been epidemics of daylight breaks-in. The appearance of these vehicles can be changed in a few minutes. Even the coachwork is built up under conditions of secrecy in the police garage; its characteristics are changed whenever it is suspected that its true purpose has been discovered or the vehicle has become too familiar locally.

The aerial is concealed inside these vehicles and the radio is used to report the progress of a special mission to the operations room or to summon assistance if required. Being permanently "on the net," they can join in any action which crops up while they are on duty if the emergency is sufficient to warrant it.

A call for police assistance is received direct into the operations room either by telephone (in addition to the private telephones in the city, there are 149 public telephone kiosks, 127 police/fire standards and 36 police boxes, all of which display instructions for use by civilians) or from one of the 10 police stations, all of which are linked to the control room by telephone and 4 having also 7-watt transmitters and receivers; or, in the case of crimes committed outside the city (such as a stolen car believed to be heading for Nottingham) over the Home Office Regional wireless scheme, the medium wave transmitter now



at Stanton-on-Wold serving six counties—Nottinghamshire, Derbyshire, Lincolnshire, Leicestershire, Northamptonshire and Rutland. The latter was originated by Capt. Popkess in 1934 and maintained by the Nottingham City Police until handed over to the Home Office in 1939.

While the operations room was being inspected, it was reported that a stolen car was believed to be approaching Nottingham from the North.

The officer on duty in the control room ordered "Action"—and when this had been broadcast, together with a description of the stolen vehicle and its registration number, all lights on the map were extinguished and three new lights appeared at the top of the map. This indicated that the officer has posted three uniform cruisers at strategic points at the northern approaches to the city.

Five minutes later, one of these cruisers reported that he had sighted the stolen vehicle, that it had entered the city and he was following in pursuit.

This message was broadcast from the control room, and a further "Action"—was ordered. Immediately, further lights appeared on the map, ringing the city.

The trap was now set. The car was in the net and it could not get out. All exits from the city were barred by police patrols.

The pursuing police car reported as frequently as necessary the route taken by the wanted car and at every cross-roads whether there had been a change of direction. All these messages were immediately broadcast from the operations room so that all the cruisers engaged knew whether any action by them would be required.

In the garage, a motor-cyclist stood-by with his "chaser" ready for action—ready to race off if an unexpected change of direction gave him a favourable chance to intercept the stolen car.

Back in the control room the chase was followed on the map as clearly as if two minature motor-cars were travelling over it.

Eight minutes after the start it was seen that the stolen car and its pursuer were heading for one of the southern points where a patrol car was waiting.

The second patrol car slowly pulled across the road and three minutes later it was reported that the stolen car had been stopped and the driver arrested.

Radio has produced a number of sensational arrests in Nottingham.

Shortly before Christmas it was reported at 11.18 p.m. that there was someone in a lock-up grocer's shop. A message was put out to two of the cruisers on patrol in the vicinity. The driver of the first police car to arrive at the scene instructed some civilians to guard the front and

side entrances of the shop. He then scaled the wall and apprehended three youths who had broken into the premises and were in possession of cash and confectionery they had stolen. The second cruiser arrived on the scene at 11.22 p.m.—four minutes after receipt of the initial message—to find the prisoners being loaded up in a van.'

Recently a uniform cruiser spotted a motor-car which had been reported the previous day as stolen from Radcliffe on Trent. He informed the operations room, chased and overtook the car and stopped it. The driver was arrested and later admitted eleven cases of car stealing, 13 house-breaking offences and four cases of larceny.

An exciting chase took place when a cruiser reported at 1.15 a.m. that he had seen a lorry laden with coal which had been reported a few minutes earlier as having been stolen. Reporting his progress by radio to the operations room, the cruiser chased the lorry through the city. The lorry finally crashed through closed level crossing gates and came to rest on the railway track where the driver was arrested.

A uniform cruiser saw a motor-van, without lights being driven in an erratic manner at 11.40 p.m. He overtook and stopped it. The driver was drunk and became violent. The officer used his radio to obtain assistance.

Once it was reported that a soldier had been seen in a private house. The operations room ordered a concentration of vehicles and they arrived in time to see the soldier running across some fields. The cars could not follow. Two officers gave chase on foot while one car went by a roundabout route to intercept, and surprised the soldier in a spinney. The soldier ran down a narrow lane where the car could not follow and again threw his pursuers off the scent but he, was by now a marked man. Every move was reported back to the operations room where the plan was co-ordinated. The chase lasted an hour and a half and ended with the soldier boarding a trolley bus; a police cruiser overtook it, the police driver boarded the bus and arrested the soldier.

Some of the alarms received in the operations room have produced unexpected results. Once a tapping noise was heard at night on the premises of a local bank A civilian rang up the police. Patrols cars were rushed to the scene and the building was surrounded. The noise turned out to be somebody hanging pictures.

On another occasion a foot patrol phoned in the early hours of the morning tht he had seen a suspicious light in an office. Assistance was directed to the scene by radio. The officers forced an entry and found a man asleep on the couch. But he turned out to be the owner of the office.

The Nottingham City Police was one of the first Forces in the country to adopt two-way wireless communication. A start was made in 1932 When Mr. H. B. Old, now one of the Home Office regional wireless engineers, was taken on the staff of the Force as wireless engineer. Morse Telegraphy was then used and the first set was constructed by members of the Force at a cost of about £40. This consisted of a two-valve receiver and a 35 watt transmitter and was installed in a van.

The main transmitting station was also equipped by wireless enthusiasts in the Force. This had a 4 valve receiver and a 40 watt transmitter, and the materials cost £100.

The elaborate equipment in use today is valued at £4,500, while the N.F.S. radio equipment operating in the same scheme cost £1,800.

As modern methods have progressed, Nottingham have improved and enlarged their system until today they have one of the most highly efficient police radio scheme in the country.

They run their own school where every member of the Force—over 400 strong—attends the three-weeks course, and periodic "refresher" courses as new apparatus or new operating procedures come into being. Here, in addition to learning the technicalities and methods of operating, they are schooled in voice training.

Even the foot patrols attend these classes, so that they can operate the equipment in an emergency or can be switched to the Mechanised and Communications Division if necessary.

It has never been intended that this highly mobile radio team shall replace the homely foot patrol. The Nottingham Mobile Organisation is superimposed on an area covered by 80 foot patrols.

Says Capt. Popkess, Chief Constable of Nottingham and pioneer of police radio: "The primary function of the police mechanised Division is to deal with crime on wheels and certain other types of offence in which speed is essential."

In an article published in the *Police Journal* 12 years ago he wrote: "Although the patrol man is, and will long remain, the backbone of our police system, his methods must be brought up-to-date to cope with rapidly changing conditions. Future developments in the Police Service should be towards greater mobility and more efficient means of communication, both locally and nationally.

"It would be ridiculous to make up our minds that, because wireless telephony cannot at present be put on the air on a wavelength of 145 metres without serious interference with ordinary broadcast programmes, the possibilities of wireless telephony as a means of communication for police purposes are not worth considering further.

"The main thing is to devise that best method of two-way communication. At present we find it is by telegraphy, but we are satisfied that the interference of police telephony with broadcast listeners can be practically eliminated, providing a very short wavelength is used."

The Nottingham scheme, under his guidance, has moved a long way towards perfection since he wrote those words.

"EVEREADY" TYPE 2036 CYCLE CASES.

National Carbon Pty., Ltd., have recently landed further supplies of EVEREADY Type 2036 Cycle Cases. These are now being distributed to accredited EVEREADY distributors, and dealers should be able to obtain their requirements from their usual source of supply.

SIGNAL - TO - NOISE RATIO

In the younger days of radio it was very difficult to construct amplifiers containing more than a few stages, mainly because the phenomenon of instability was not very well understood. In addition, the valves and components in use at the time were not very suitable for multi-stage amplifiers. However, before many years had passed, valves and components were available which, with increased knowledge of the principles involved, enabled very stable high-gain amplifiers to be built quite easily.

It might then be supposed, therefore, that the problem of amplification was solved, but, as with many problems, the apparent solution brought a new trouble in its wake—the question of "noise."

Before the advent of the high-gain amplifier it had been thought that no signal was too weak to be detected if enough amplification were used, but this was soon shown to be quite wrong. The trouble is that with any amplifier, if the gain is great enough, a kind of hissing noise can be heard in the output, even if no signal is applied. This noise is known, in the light of the electron theory, to have two main sources, but one cause—the movement of electrons.

SOURCES OF NOISE.

First of these sources of noise is the valve itself. The flow of electrons from cathode to plate inside the valve is not a smooth uniform flow, but consists of the sum of all the currents caused by the millions of individual electrons which break loose from the cathode, or filament. This discontinuous nature of the emission causes minute fluctuations of the plate current—much too small to be seen on any meter—which are amplified by succeeding valves and finally appear in the output as "shot effect" noise. By applying the laws of physics to the problem, it is possible to calculate the magnitude of the shot effect noise in a particular case, but if the noise is measured, it is found that a good deal more exists than can be accounted for by the "shot effect" alone.

The remaining noise does not arise (for the most part) in the valves, but in the circuit components such as grid and plate resistors, or inductances if they are present. It also is due to the behaviour of electrons, and comes about in the following manner. The electrons in the atoms of all materials are in constant vibration, or agitation. In conductors, such as a piece of copper wire. the outer electrons of the atoms can move quite freely, and actually do drift along the wire when a potential is applied to its ends; this drift is the electric current. Under normal conditions of no applied potential, however, the electrons are vibrating about their average positions. Now these vibrations are themselves minute electric currents and their sum in a particular coil, or resistor, does build up very small voltages across the coil (or resistor). These voltages are far too small to be measured, but if applied to an amplifier they too will be heard in the output along with the shot noise.

Now these two sources of noise, shot effect and thermal agitation, as it is called, are inherently present in all amplifiers to a greater or lesser degree, so that if an attempt is made to amplify very minute voltages with a high-gain amplifier, the circuit noise becomes comparable in magnitude to the signal. Thus, the noise sets a limit to the smallness of the signal that can just be detected, for if the latter is much weaker than the noise, it cannot be heard at all, however much amplification is used.

Luckily most apparatus, such as microphones and gramophone pick-ups, has a high enough output voltage to make amplifier noise harmless, but the question of noise is of great importance in the picking-up of very weak radio signals, and in the application of many photo-electric devices.

All the foregoing has purposely been made quite general, for although the main interest may be in radio reception, a radio receiver is only a special type of amplifier, and very often has a gain of a million times, or even more. From now on, though, the discussion will be confined to radio sets.

WHAT CAN BE DONE ABOUT IT?

With this explanation of how and why noise is generated by a receiver itself, the question arises as to what can be done about it. The usual way of indicating the sensitivity of a receiver takes no account of this set noise. For instance, two different sets could have the same sensitivity, as measured in microvolts input for a given output, and yet one could be much less useful, because it generated much more noise than the other. This difficulty in describing the per-

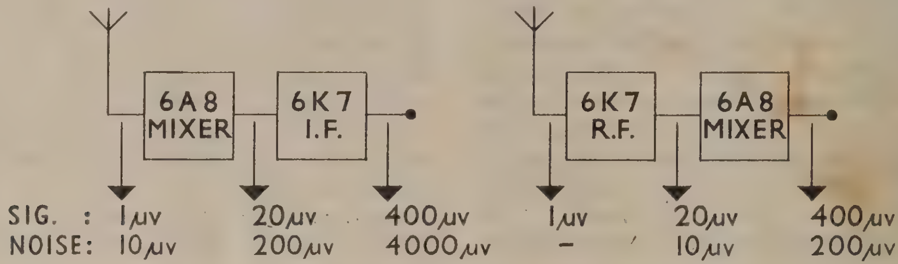
formance of a set has been solved by introducing the term signal-to-noise ratio, and methods of measuring it. From what has been said, it is apparent that as long as two sets have equal or nearly equal gain, the set which has a higher signal-to-noise ratio under stated conditions is the better set. One way of defining signal-to-noise ratio is as "the ratio between signal output and noise output for a stated input signal voltage." This would be expressed as, say, "ten times at one microvolt input" and would mean that with a signal of one microvolt at the aerial terminal, the ratio of signal output to noise output is ten to one. Other methods of defining S/N ratio are used, but a description of them is outside the scope of this article.

Of recent years, then, the electrical design of receivers, particularly those for the high and ultra-high regions, has been largely a struggle for better signal-to-noise ratio. Some valves are inherently more noisy than others, but the best valves, purely from the noise point of view are triodes. This is unfortunate, for other requirements almost exclude the triode for R.F. and I.F. amplification. Next best are the high-gain pentodes specially developed for television receivers, but these are not very suitable for the average set for other quite different reasons. Next come the ordinary R. F. pentodes such as the 6K7 and 6J7 etc., while last and worst are the special mixer valves such as the 6A8 pentagrid converter, and the rest of the multi-grid types.

DESIGN OF SUPERHETS.

This list explains why all better class superhets have at least one stage of R.F. amplification before the converter. A 6K7 used as an I.F. amplifier gives more gain than the same tube used as an R.F. amplifier. At first sight it may therefore seem more profitable to build a set with two I.F. stages rather than with one R.F. and one I.F. stage, but the former arrangement is seldom found. One good reason for this is the better S/N ratio of the latter, which is due to the high noise level produced by most converter valves. The figure below should help in consideration of this subject.

The figure shows at (a) a 6A8 followed by a 6K7 I.F. stage and at (b) the same mixer preceded by a 6K7 R.F. stage. It is assumed that in both cases the gain of the tubes is the same, say 20 times for both 6A8 and 6K7. Thus the over-all gain is 400 times in each case. Now, for simplicity assume that 6K7 is noiseless, but that the 6A8 noise is equivalent to a noise signal of 1μv at its grid. Also suppose that both arrangements are dealing with a 1 μv signal at the aerial terminal. It can now be considered that signal and noise are separately amplfied.



The signal is subject to the same amplification in both cases, and its amplitude at various points in the circuits is shown in the figure. Similarly, for the noise. In (a) the S/N ratio at the 6A8 grid is 1:10, and is not improved by passing through the circuit. It is still 1:10 at the output. At (b) there is 1μv. of signal and no noise at the input. At the 6A8 grid there is 20μv. of signal and 10 μ v. of noise since the 6A8 noise has been assumed to be all generated in the input circut. The S/N ration is therefore 2:1 at this point, and is still 2 :1 at the output of the 6A8. If these two illustrations represented actual cases circuit (b) would enable the signal to be heard, along with some noise, but in circuit (a) the signal would not be heard at all, since the noise is so much greater in amplitude.

The illustration given is somewhat idealised since the 6K7 is *not* noiseless. This does not effect the argument however, *for as long as the R.F. stage noise is much less than the converter noise, a better S/N rather is obtained than without the R.F. stage.* If, on the other hand, the R.F.

(Continued on Page 34)

PROPOSED INSTITUTE OF RADIO TECHNOLOGY (N.Z.)

The Wellington meetings in connection with the development of the proposed Institute were continued on March 6th, 1946, the whole of the evening being devoted to a talk on the subject of Radio Transmission, by Mr. G. Searle, M.Sc., A.M.I.E.E.

Mr. Searle's talk dealt with the factors and conditions affecting the propagation of radio waves in space. He defined, first of all, the spectrum in use and indicated the modes of propagation which occurred, in the following frequency divisions:—

In connection with the calculation of ground wave signal strength at varying distances from the transmitter, both Sommerfeld and Watson formulae were discussed, suitable curves being presented to demonstrate the change-over from plane ground-wave reception (Sommerfeld) and the area covered by the diffracted waves (Watson).

Other curves showed how low signal strengths varied as the nature of the earth's surface over which

Frequency.	Category.	Type of Propagation.
Below 30 Kcs.	Very low frequencies	Guided wave
30-300 Kcs.	Low frequencies	Guided wave—Sky wave
300-3,000 Kcs.	Medium frequencies	Ground wave—Sky wave
3,000-30,000 Kcs.	High frequencies	Sky wave
30 Mcs.-300 Mcs.	Very high frequencies	Direct wave, ground wave, etc.
300-3,000 Mcs.	Ultra high frequencies	Direct wave, ground wave, etc.
3,000-30,000 Mcs.	Super high frequencies	Direct wave, ground wave, etc.

He then considered the effect of the ionised layers on the transmission of waves of the above-mentioned frequencies. The D, E, F_1, and F_2 layers were discussed and mention was made of their variations during daily and seasonal changes. At low frequencies it was shown that the D layer and the earth's surface, comprised two reflecting surfaces between which multiple reflections enabled low frequency transmission to take place (analogous to the "wave-guide"). At higher frequencies, these layers were penetrated and sky wave reflections took place from the F_1 and F_2 layers, provided that the critical frequency when adjusted for angle of incidence was not exceeded. It was interesting to note that the critical frequency was increased by a factor, which increased with angle of incidence at the ionosphere, and consequently if long hops could be obtained between two points on the earth's surface, frequencies very much higher than the critical frequency could be used.

Waves were shown to behave in a manner similar to light waves and refraction, reflection and diffraction occurred.

the waves passed, varied; and it was noted in this connection, that sea-water and good agricultural land gave least attenuation.

The theory relating to the non-reflection of V.H.F. waves from the ionised layers and refraction due to atmospheric conditions was also explained and the intense interest which was taken in the whole talk, was evidenced by the discussion following at question time.

PROGRESS TOWARDS THE FORMATION.

Meetings have been held in Auckland, Wellington and Christchurch for discussion of the Name, Objects and Grades of Membership of the proposed Institute, also, groups have been formed in several small towns for the same purpose. The recommendations made are being considered by the main committees and a modified constitution will be available on application to the office of "Radio and Electronics," from the date of publication of this issue.

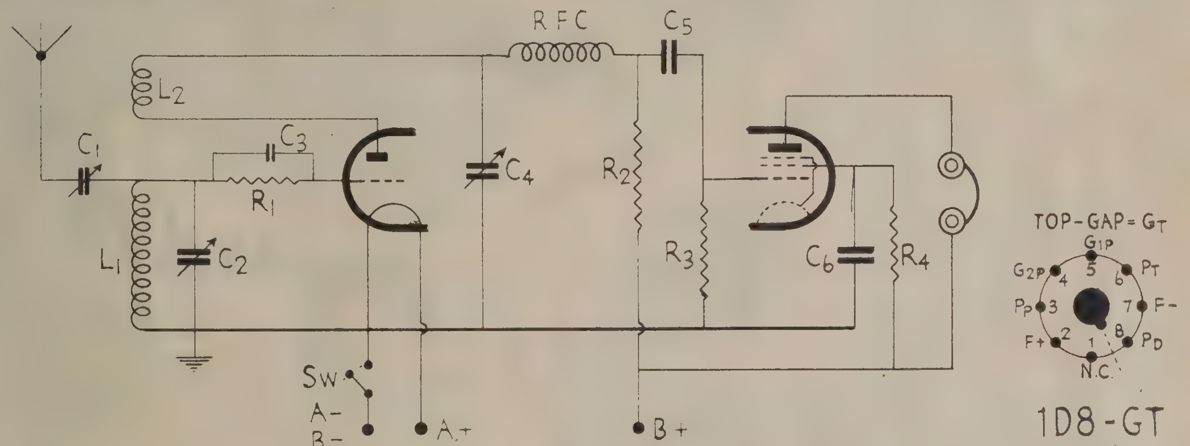
THE "RADEL" ONE

The receiver to be described is an old favourite—the regenerative detector and for the beginner, valve for valve there is nothing to surpass it for all-wave results. In referring to this set as a beginner's set, we are perhaps being a little ambitious for it is designed primarily for the enthusiast who has already had experience in constructing a small set. There is no reason why it should not be built by those who are new to radio however, so we will go into more detail as to its operation in our next issue.

Briefly the Radel One uses a 1D8-GT tube. The triode section is a regenerative detector and the pentode section is an audio frequency amplifier. The broadcast and short-wave bands are covered by plug-in coils.

late unless the reaction coil L_2 is coupled to the grid coil in the correct manner. The grid end of the grid coil must be immediately adjacent to the plate end of the reaction coil, and both coils wound in the same direction. While the component specifications given are accurate, there is a possibility that due to differences in actual construction, difficulty may be experienced in getting the set to oscillate. Should this occur it is a good idea to try an extra turn or two on the reaction coil.

The components for the receiver were mounted on a wooden base board 5½-inches x 8-inches, and the panel used was a piece of steel sheet 8-inches x 6 inches. The use of a metal panel is very desirable for in an unshielded set hand capa-

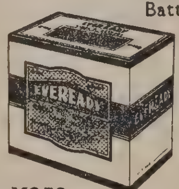


C_1 = 30 $\mu\mu f$. max. trimmer.
C_2 = 0.00035 μf. max. variable.
C_3 = 0.0001 μf. fixed.
C_4 = 0.0003 μf. max. variable.
C_5, C_6 = 0.1 μf.
R_1 = 2 Megs.
R_2 = 50,000 ω.
R_3 = 5 Megs.
R_4 = 20,000 ω.

A study of the circuit will show that the antenna is connected directly to the input circuit of the detector by means of a small variable condenser and for this purpose we have used an ordinary trimmer condenser. The R.F. tuning circuit consist of the coil L_1 and tuning condenser C_2. Regeneration is obtained by the coil L_2 and the reaction control is a .0003 μf. mica dielectric condenser C_4. It is as well at this stage to issue a word of warning on making coil connections. The detector absolutely refuses to oscil-

city effect renders tuning, particularly on the short-waves, very difficult and the extra trouble in constructing a metal panel is more than compensated for by the results achieved. The panel should be well earthed and care should be taken to ensure that the 'phone jack is well insulated as it carries H.T. The accompanying photographs serve to illustrate the chassis layout and it can be seen that the valve is mounted on the centre of the base board. This gives free access to the socket pins for both the detector and pentode sec-

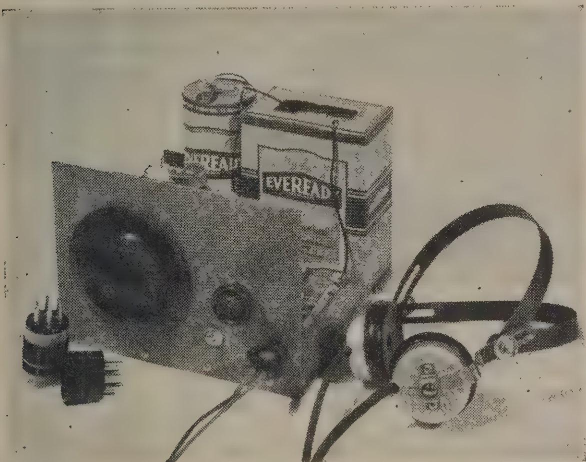
EVEREADY



EVEREADY

tions of the valve.

In mounting the valve socket, spacing rods of approximately $1\frac{1}{4}$ inches should be used in order to firmly anchor the socket to the baseboard and at the same time make room for soldering the wires to the socket pins. This form of socket mounting should also apply to the coil socket for the same reasons as outlined above. The coil is located immediately behind the tuning condenser and the aerial coupling condenser is mounted on the aerial terminal.



All the small components such as the four resistors, the R.F. choke, the coupling condenser and the pentode screen by-pass condenser are self-supporting. In the interests of both mechanical and electrical construction all leads should be as short as possible. It is important to note that the screen by-pass condenser should connect as close as possible to the screen terminal on the valve socket.

The grid condenser and resistor are connected to the top solder lug of the tuning condenser so that the shortest possible lead connects with the top-cap grid of the triode section of the 1D8.

The coil specifications are given in the chart and it matters little which pins are used in the coil socket provided the choice of connections remains standardised throughout the set of coils. Some trouble may be experienced in obtaining coil former, but we used $1\frac{1}{4}$-inch former and ordinary six pin speaker plugs. It was found that the former fits perfectly over the end of the plug and a really good glue will firmly set the two together. This type of construction is only necessary for the broadcast and intermediate coils—the high frequency coil is wound on an old valve base. It may appear a little odd that six pin coil

COIL DATA.

Broadcast.

L_1 105 turns 36 gauge enamelled wire, close wound.

L_2 30 turns of same wire, close-wound.

Short-Wave A (approx 19m.—60m.)

L_1 16 turns 24 gauge enamelled wire, double spaced.

L_2 10 turns of same wire close-wound.

Short-Wave B (approx. 30m.—90m.)

L_1 6 turns 24 gauge enamelled wire, double spaced.

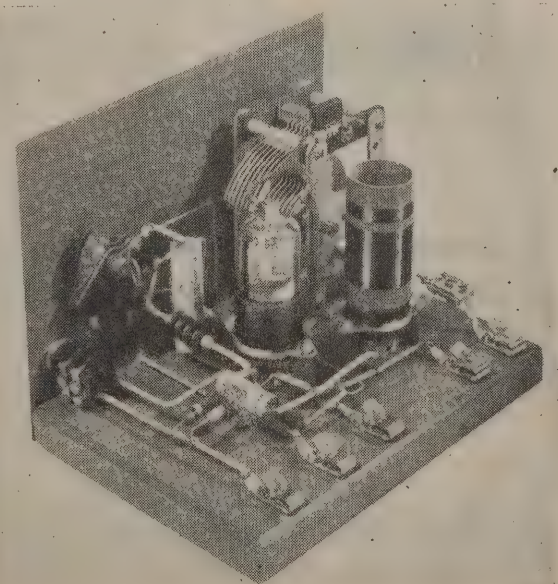
L_2 10 turns of same wire close-wound.

Note.—All tickler coils spaced $\frac{1}{8}$in. from top of grid coil.

formers are specified, but we have in mind an R.F. stage which we will describe in the future and the two extra pins will provide the connections for a primary coil which will be used for coupling the R.F. stage to the detector.

The high frequency coils should be double spaced, and so that they will not shift when wound a coating of a clear cellulose lacquer is advisable.

The adjustment of the set is not difficult and to all who have used regenerative sets the setting up is comparatively simple. When the reaction condenser is turned to a particular point a hissing sound can be heard and if then the aerial



terminal is touched with the finger or with the aerial, a distinct "plop" will be apparent. This denotes that the set is in an oscillating condition. For 'phone reception the reaction control should be turned just below the oscillating point but for C.W. reception the set should, of course, be oscillating. The adjustment of the aerial coupling condenser is quite critical and for maximum efficiency may need to be reset for each change of coil. Should the coupling be too great the set may not oscillate at some part of the tuning range It is therefore essential to try different amounts of coupling when ascertaining whether or not the set will oscillate. The set is powered by dry batteries—a $1\frac{1}{2}$ volt "A" and a 45 volt "B" and for the small amount of filament and plate current used, they will last a considerable time.

The 1D8-GT has only the one filament, which supplies the triode, pentode and diode sections of the valve. On the circuit, the diode has not been shown at all since it is not used, and for clearness, the circuit has been drawn as though triode and pentode were separate valves. To simply further, a filament has been shown dotted for the pentode section. At the left is a socket connection diagram for the valve. This diagram assumes that one is viewing the underneath of the valve socket.

The set we have described works really well. The overseas short-wave reception is excellent and has to be heard to be believed; there is, however, one final hint. The receiver is capable of good performance provided it is on the end of a good aerial and earth system.

A 5in Service Oscilloscope from page 11.

be used to compensate for astigmatism of the tube.

In the full circuit diagram, R_{21} is the Y astigmatism control. Varying this resistor increases or decreases the anode voltage of V_2 and V_3 simultaneously. For example, each may move up by 20 volts, so that the potential *between* them remains as before. What has changed is their potential with respect to the final anode, which is now + 20 volts. In practice it will be found that this is exactly borne out.

This completes the list of "tricks" played by the cathode-coupled stages, which determine the operating characteristics of the whole instrument. All the advantages that have been detailed are in addition to those common to all push-pull circuits, such as stability and inherent hum reduction.

(To be continued.)

(*Measurement of Frequency from p. 14*

of enabling frequencies to be measured that are not harmonically related to the standard. Fortunately, very simple methods exist for achieving this desirable end. Simplest among them is the use of an auxiliary R.F. oscillator.

THE AUXILIARY OSCILLATOR.

This can have any frequency that satisfies two conditions. First, it must be equal to or lower than the standard frequency. Secondly, the standard must be one of its harmonics. Since it is the basis round which a complete secondary frequency standard is constructed, we will assume that the auxiliary oscillator has a frequency of 1 mc/sec. WWV has transmissions on 10 mc/sec. and 5 mc/sec., both of which are received in this country. A 1 mc/sec. oscillator therefore satisfies the conditions with respect to either of these transmissions, so that each may be used as the standard, the choice depending solely upon which gives the best reception at the time of measurement.

METHOD OF USE.

This is simplicity itself. The standard frequency is tuned in on the receiver, and a fine tuning control on the auxiliary oscillator is used to set the latter so that its appropriate harmonic is at zero beat with the standard. *The auxiliary has now been set exactly to a frequency of 1 mc/sec., and can now be regarded as the standard frequency.*

If the auxiliary is not rich in harmonics (which will be the case with any very stable oscillator except the electron-coupled variety) a distorting or harmonic amplifier may be used following the oscillator to increase the harmonic content of the output. If this is done, the oscillator produces a series of standard frequencies starting at 1 mc/sec. and spaced by 1 mc/sec., to as high a frequency as the harmonics extend. Thus, with a small secondary frequency standard comprising only a 1 mc/sec. oscillator and a harmonic amplifier (two valves are all that is necessary) known frequencies of 1, 2, 3, 4, 5, etc. mc/sec. can be produced up to at least 25 or 30 mc/sec.

The important question now arises, "how can these frequencies be identified one from the other?" Discussion of this point will have to be left for the next part of this series, in next month's issue.

THE INFINITE-IMPEDANCE MIXER

This circuit is a war-time development which can be expected to find a place in post-war equipment. It has outstanding advantages for use in amateur or communications receivers.

As far as is known, the infinite impedance mixer first made its appearance in a certain type of airborne radar equipment which had a signal frequency in the region of 200 mc/sec. Though not always the case with U.H.F. circuits, the advantages of this one may very easily be "transplanted" as it were, to the lower frequencies, with no loss of efficiency.

The usual reason for not applying U.H.F. techniques to lower frequencies is that the special circuits used above, say, 100 mc/sec. are not profitable lower down the frequency scale, but this objection does not apply to the present case.

VERY LOW NOISE.

The chief advantage of the infinite-impedance mixer is the extremely low noise-level generated by it. In fact the inherent noise is so small in magnitude that unless special precautions are taken, an R.F. stage in front of it may actually *increase* the set noise! Next in importance is its high input impedance, from which it derives its name. This is a great asset at any frequency, since the selectivity of the input circuit is greatly increased, resulting in a much improved image ratio.

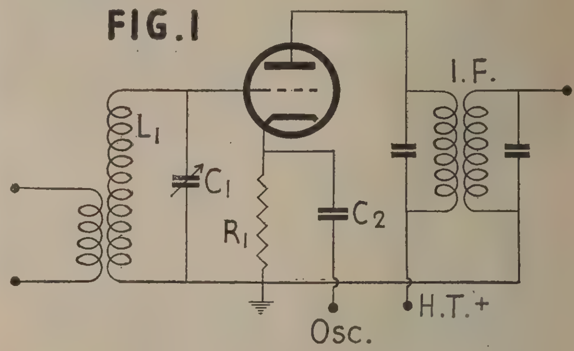
HOW IT WORKS.

Fig. I shows the basic circuit. L_1 C_1 is tuned to the signal frequency. Oscillator voltage is injected into the cathode circuit through the blocking-condenser C_2. The I.F. is taken off in the usual manner through a transformer in the plate circuit.

Now the signal frequency is much higher than the I.F. so that the transformer in the plate circuit can be considered non-existent as far as signal is concerned. The valve therefore acts as an over-biassed cathode-follower to the signal frequency, with 100 per cent. negative feedback, exactly as in the cathode follower. Like the latter, therefore, the circuit has a very high grid input impedance, the capacitative component of which is non-effective since the input circuit is tuned.

The cathode resistor R_1 is sufficient to bias the valve very nearly to cut-off. The result is that the circuit performs at the same time as a biassed detector, without in any way affecting the input impedance. The reason is that it is virtually impossible for the valve to draw grid-current. For this to happen, a signal of 80 volts or so would be required.

FIG. I

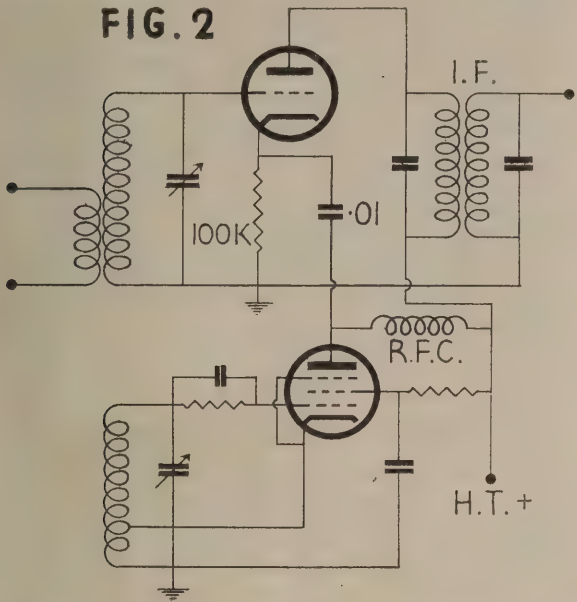


CATHODE INJECTION.

The use of a triode mixer stage is not in itself a new idea. The first superhets used them, for there were no other valves to use, but their characteristics were not all that could be desired. A great difficulty was that of injecting the oscillator voltage in such a way that the oscillator tuning was not "pulled" by the mixer tuning control. The circuit used here does not suffer in this way if due precautions are observed. One method is to use an electron-coupled oscillator as in Fig 2. The oscillator voltage is fed directly from the oscillator plate to the mixer cathode through a $0.01\mu f.$ condenser. The use of an R.F. choke in the oscillator plate circuit should be noted. In an experimental mixer circuit it was found that the increase in set noise was very marked when a resistor was substituted for the choke. The reason for the increase of noise is the resistor itself. The noise generated in it by the passage of D.C. modulates the R.F. produced by the oscillator. This modulation is passed through the mixer in the same

way as signal modulation, and appears in the output of the set. Another method of taking off the oscillator voltage is illustrated in Fig. 3. The oscillator can be a simple Hartley, as shown, or electron-coupled as before, but there is no advantage in the latter with this arrangement. Here, the cathode of the oscillator is connected straight to the cathode of the mixer via the blocking condenser. This connection has an advantage in that the impedances are fairly accurately matched. It is quite a simple matter with the circuit of Fig. 3, so to adjust the cathode tap on the oscillator coil that the oscillator output is constant over quite a large frequency range. The oscillator output is higher with this circuit than with that of Fig. 2.

FIG. 2



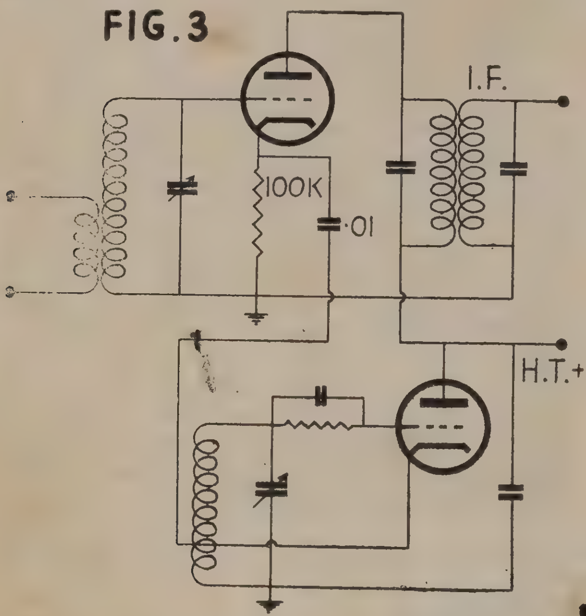
GOOD LINEARITY.

The infinite-impedance mixer has yet another outstanding property which is of greater interest to the engineer than to other workers—extremely good linearity of the output-input characteristic. Using the circuit of Fig. 3, in which the mixer was a 6C6, triode-connected, it was found that for any value of injected oscillator voltage greater than 10 volts, the I.F. output varied linearly with signal input voltage for signals from 0 to 1 volt R.M.S. The experiment was performed at frequencies of 5, 10 and 20 mc/sec., with an I.F. of 465 kc/sec. The oscillator voltage was measured at the mixer cathode with a General Radio V.T. voltmeter. A similar voltmeter was used

to measure the signal voltage at the mixer grid, the oscillator having been turned off, since a large oscillator signal appears at this point especially at the higher frequencies.

This property makes the infinite-impedance mixer ideal for field-strength measuring receivers, where linearity of the mixer is a prime consideration.

FIG. 3



CHOICE OF VALVES.

Almost any of the small triodes will work well in the circuits given. The value of the cathode resistor is not critical and may be fixed at 100,000 ω, irrespective of valve type. Choice of a suitable valve may be governed by mechanical considerations, e.g. the desirability or otherwise of a valve with a top-cap grid connection.

In one receiver which was modified to use the circuit, the original mixer was a 6C6 with screen injection of oscillator voltage. By tying screen and suppressor to the plate, and by using the oscillator coupling (already there) of Fig. 3, the modification was made without the need for any mechanical alterations to the set.

LOW FREQENCY USE.

If the circuit is used in an all-wave set it may be found that on the low frequency end of the broadcast band, the mixer breaks into a violent oscillation. The cause of this behaviour, should it occur, is that the reactance of the I.F. tuning condenser in the plate circuit is too high at the signal frequency, which is now not very far from the I.F. This causes a signal voltage to appear in the plate circuit and to be fed back through the grid-plate capacity, giving rise to the oscillation. One cure is to use a first I.F. transformer whose circuits have a lower L:C ratio. An easier solution is to shunt the mixer grid circuit with a resistance just low enough to stop the oscillation. (The latter would not meet the case in a field-strength receiver, since the regeneration still present would spoil the linearity.) The resistance need be placed only across the broadcast coil, and not directly from grid to earth.

If the receiver applies A.V.C. to the mixer, this will have to be removed as part of the modification.

"RADIO AND ELECTRONICS"

When replying to advertisements please mention our name—it helps us both.

OUR GOSSIP COLUMN

Calls at Nationol Carbon Pty., Ltd., revealed great activity. Found C. H. Hart, sales manager, back on the job in conference with T. Jamieson; he told us that M. O'Sullivan, North Island field representative, is back on his territory, whilst a newcomer, T. Joseph, is on the job as South Island representative. Both these chaps are looking forward to contacting all dealers within the next month or two.

R. D. Greenwood, managing director, has just returned from a flying visit to Australia. Whilst there he learned of the expansion of the "Mini-Max" battery plant; this should result in Australia being able to supply the requirements of New Zealand for Mini-Max Hearing Aid batteries and Mini-Max Portable Radio batteries, and National Carbon hopes to be able to release these products in the near future.

Mr. H. W. Swan, managing director of the Swan Electric Co., Ltd., who went to England last August to study the latest methods of speaker and resistor production and latest developments in all radio and electronic instruments, returned to New Zealand on March 28th. On his way home he came via Canada and the United States, where he also looked into industrial developments there.

Looking in on Radio Corporation we found Mr. R. S. Richards home again after four years in the Middle East while serving with the Air Force. Bob will be remembered by those who visited the Centennial Exhibition as the demonstrator at the Columbus exhibit, during which time he became an expert at frying eggs on the "magic plate." After his overseas experience, can we expect some modernised form of Eastern magic? Good luck, Bob, and here's to bigger and better eggs!

Ex-Flight-Lt. J. W. Wilson, who entered the R.N.Z.A.F. early in 1940, has just returned to the sales staff of Standard Telephones and Cables. Mr. Wilson will be outside sales representative for S.T.C., and we welcome him back to "Civvy Street."

PUBLICATIONS RECEIVED

"RADIOTRON EQUIVALENT TYPES CHART." "RADIOTRON CHARACTERISTICS CHART."

These two pamphlets are excellent additions to the Radiotron series of technical booklets. The former consists chiefly of a [illegible]-page table of American receiving valves including obsolete types, and valves with type-numbers peculiar to certain manufacturers. The bulb-type, and filament characteristics are given for each valve, together with data concerning exactly or nearly equivalent types, as a guide to replacement. This information should be most welcome at a time when exact equivalents are not always available. There is also an excellent appendix dealing with specific problems encountered in substituting one type of valve for another. Section (3) of the appendix is the only complete description we have seen of the eexact meaning of the many suffixes (GT, LM, etc.) used after the type number proper.

The Characteristics Chart gives in tabular form, characteristics and typical operating conditions of all Radiotron receiving valves.

"RADIOTRONICS DIGEST."

The Amalgamated Wireless Valve Company advises that every effort is being made to produce "Radiotronics" or a similar bulletin during 1946. In the meantime a smaller publication entitled "Radiotronics Digest" is being issued to all old subscribers to "Radiotronics." The third issue of the digest contains advance information on a new A.C. single-ended GT range of tubes. There is, in addition, a list of types for use in 1945-46, showing which ones are to become standard for new equipments, and which are being produced for replacement purposes only.

It is interesting to note that in the near future two miniature A.C. types will be produced. Their type numbers are not announced, but they will both be high mutual conductance R.F. pentodes, one of which will have a remote cut-off characteristic, and the other a sharp cut-off. Also forecast is an improved converter tube for the 2-volt D.C. series. This will replace the 1C7-G.

For these three publications we are indebted to the Amalgamated Wireless Valve Company, and their New Zealand agents, the National Electric and Engineering Co., Ltd., Wellington.

MAZDA VALVE DATA.

To the Edison Swan Electric Co., Ltd., London, we are indebted for a copy of their loose-leaf data book on Mazda valves. This comes at a most opportune time, for English valves will soon be more readily available than they have been in the past.

Transmitting types, cathode ray tubes and special purpose types are all included. Of particular interest is the Battery Economy series. These are two volt filament tubes with a small spray-shielded envelope and Mazda Octal bases. Their characteristics (at 120 volts on the plate and a minimum bias for the R.F. tubes) compare more than favourably with their American counterparts. For example, the V.P.23's characteristics are as follows: Filament, 2v., 0.05amp. Plate current 1.45 m.a., Screen current 0.5 m.a., Gm. 1.08 m.a./volt. In the whole series the only one which appears to have inferior characteristics is the triode-pentode converter valve. Constructors of portable 2 volt receivers would do well to investigate the possibilities of the remainder of the series, as they have unusually good characteristics for low-drain battery valves.

Signal-to-Noise Ratio from page 22.

is noisier than the converter, it is better to omit the R.F. stage.

It would seem from the above that in obtaining a good signal-noise ratio, the most important valve is the first in the set, and this is the case. It is quite possible to design a mixer whose inherent noise is so low that it does not pay, from this point of view, to use an R.F. stage in front of it, but that will have to be left for another article. In the meantime, it is well to remember that adding an extra I.F. stage will not necessarily improve the receiver at all, and may even reduce its S/N ratio, if the "front end" is particularly good.

BROUGHT FORWARD:

The following is the piece missed last month from the Condenser Tester.

(1) The "high" side of the D.C. supply is at a negative potential so that the *positive* terminal of the meter must be connected to the chassis.

(2) Always start the leakage test on the highest available voltage range of the meter.

(3) Always turn off the power supply before connecting or disconnecting a condenser from the terminals.

(4) Do not test condensers at more than their rated D.C. voltage, if this can be avoided. If the rating voltage is unknown, advance the control slowly to 200 volts and carry out the test. If it is satisfactory give the condenser a higher voltage and try again. Even a 200 volt condenser should stand up to a short test at 600v.

This page is contributed monthly by the New Zealand DX Radio Association (Inc.), 20 Marion Street, C.2, Wellington, New Zealand. All "DX" and Club enquiries should be addressed direct to the Association.

THIS "DX-ING"

On shortwave, certain wavelengths or frequencies are best for day-light reception . . . 25 metres to 13 metres for example. Night reception is generally best from 25 metres to 200 metres. Conditions may vary from day to day, even hour to hour, so that the keen DXer has to be very patient and systematic. If a station fades out, **don't** tune on something else, hang on to the station—the waiting game pays in DXing! When the station comes out of the fade, it may be louder than before, and prove to be a rare catch. Always have a pencil and paper within reach to jot down any announcements made. "Location" of the receiving station has a marked effect on results, some districts being better than others. Many and varied are the types of aerials used by DXers, and directional effects may be introduced if desired. Time is a complicated factor in DXing, directly affecting the listener, as he may be getting ahead or behind his local time in his ether searching.

These and other similar factors enter into this "King of Hobbies," but require no technical knowlege. Briefly, then, success in DXing depends on being "in the know" as to where and when to tune. Any recognised DX club will provide any information required, and usually publish a monthly journal in which the members report what is being heard. Time charts, report forms already to fill in, call list, etc., are usually supplied by DX clubs, thus simplifying the hobby.

To take up the hobby seriously, no station should be logged or written to for verification of reception, unless the call letters have been heard beyond any reasonable doubt. To assume that you heard a certain station because you caught a programme on that channel is like conceding yourself a hole in golf.

You do **not** need a special set, an expensive aerial or a lot of fancy gadgets to be a successful DXer Any average set and aerial will produce results, provided the DXer does not lose patience. DXing being a test of the radio engineers' skill just as speed racing is a test of the motor mechanics' skill, the apparatus (set, aerial and earth) should be in good repair. Any old sort of wiring simply won't do . . . aerial and earth wire joints should be properly soldered to assist in passing on those minute DX signals.

The question often asked is this: "What part does the DXer play in the radio broadcasting industry?"

To answer this, we must consider the matter from many angles. By some, DXing is described as a disease implanted by a bug. The origin of the bug seemes to have come to light during the early history of radio broadcasting. We might say that the larva of the bug was found at the tip of the deceased cats-whisker.

DX, during the reign of the crystal set, was the reception of anything beyond the back fence. The introduction of the single tube increased the scope of the term to as great a distance as one thousand miles. With the development of multiple-tube receiver and the perfection of higher powered transmitters, DXing reached the stage where we find it possible, today, to receive broadcasts from all parts of the globe.

The hardened critic might say that this development issues the sentence of death to the DX bug. The fallacy of this is found in the ever-increasing number of applications received for membership in the New Zealand DX Radio Association Inc., as well as in similar organisations throughout the world. What is the cause of this increasing interest in DXing?

Is it not true that a person's hobby holds more fascination for him when he discovers someone else with the same interest? This being the case, it might be assumed that one person with any interest in DXing having found another with a similar interest, will endeavour to locate more who are bitten by the same insect. This has been the case in recent years and has brought about the formation of DX clubs. While the massing of people with common interests to form clubs is not, in itself, new, nevertheless it tends to inaugurate policies which have the effect of developing new ideas.

The broadcaster may not be a DXer himself, but his presentations are affected in a large measure by the DXer, although he may not be aware of the fact. The ordinary listener is often a DXer without realising it. On various occasions he may find himself obliged to tune in distant stations in order to hear the type of broadcast not provided by his local stations. The reception of this distant broadcast may be affected in some manner by atmospheric conditions, or the programme may be so presented as to bring criticism or commendation from the listener. Through the interest which he has found in the reception of this distant station, he has become, in effect, a DXer.

Those of us who have had the opportunity of visiting club members and broadcasters at distant points, have found them to be real sportsmen in every sense of the word. Of course, we all recognise DXing as a major indoor sport. We find that the **real** DXer PLAYS the game in a straight-forward manner. This is recognised by some broadcasters who assure us that they are more than willing to play the rules in the same respect. DXers should enclose return postage, as the stations have a huge DX mail. The more

we see of this DXers' world, the more we realise the magnitude of it all. Although there are some who don't believe it, neverthless we find the DXer is a rational human being. We see that his interests have had tremendous power in developing the industry of radio broadcasting. It is observed that he is not a person to be pitied, but rather someone to be respected for his share in perfecting the finest sources of enjoyment known today.

The DXers' world is not confined to the art of dialling for distant transmissions. Instead, it embraces every factor vital to radio broadcasting. Through his suggestions and criticisms, programmes may be made more interesting and technical faults minimised.

We see that the engineering, announcing, programme direction and presentation, and in fact, every phase of radio broadcasting is influenced by, and we might add dependent upon, the reactions of the DXer.

So, listeners, we conclude our general discourse on the DXing hobby. The Headquarters Executive wishes you good reception and . . . cheerio, till we meet again.

BROADCAST.

A new Australian National unit is to operate on 560 Kcs from the state of Queensland; this will mean 6WA will move to 570 Kcs. No call sign is yet designated to this station, but it is scheduled to commence testing soon.

Radio Moscow, 832 Kcs, 5 a.m.

Radio Moscow, 950 Kcs, 5 a.m., address Radio Centre Moscow.

KABC, 680 Kcs, reported testing after 6 p.m., may be on all night.

KALE, 1330 Kcs, Portland, Oregon, closing 8 p.m., after KALE signs KFAC is heard.

KIO, 1380 Kcs, Boise, Idaho, closes 7 p.m.

KSO, 1460 Kcs, Des Moines, Iowa closes 7 p.m.

KCMO, 1480 Kcs, Kansas City, Missouri, closes 7 p.m.

Checking Grid-bias Cells

A number of domestic radio sets, particularly the 6 volt vibrator type, use electro-chemical cells for supplying the various grid-bias voltages. These cells can only be accurately checked with a vacuum-tube voltmeter, for they are designed to generate a no-load voltage, and their current capacity is less than one micro-amp.

If a V.T.V.M. is not available, the bias cells may be checked by placing a milliameter in the plate circuit of one of the valves, and comparing the plate-current (a) with the bias cells, and (b) using a known bias equal to the nominal voltage of the bias cells.

If the plate-current is too high with the bias cells in circuit, it may be assumed that they are under their rated voltage.

Printed by Harry H. Tombs, Ltd., 22 Wingfield St., Wellington, New Zealand.